Using insects to protect crops

Biological control of aphids

AQA: 3.5.3 Energy and ecosystems
Edexcel A: 5 On the wild side
Edexcel B: 10.4 Human effects on ecosystems
OCR A: 6.3.2 Populations and sustainability
OCR B: 4.3.1 Photosynthesis, food production and management of the environment
WJEC Eduqas: 2.1.6 Human impact on the environment

Aphid feeding

Lucy Alford

Zoologist and insect physiologist Lucy Alford explains how biological control might be used as a valuable green alternative to pesticides

Aphids, the most familiar of which are greenfly, are major pest insects worldwide. These small creatures, only a few millimetres long, belong to the insect order Hemiptera (true bugs). They feed on the sap in the phloem of plants using specialised mouthparts known as stylets, formed from modifications to their mandibles and maxillae. Aphids cause great mechanical damage to the plants when they pierce and penetrate the phloem to feed on the sap inside, and they can spread plant diseases. This is why aphids are considered one of the most important groups of agricultural pests. They are capable of transmitting almost 300 plant virus species — more than 50% of all plant viruses spread by insects.

Key words

- Agriculture
- Aphid
- Biological control
- Chemical control
- Parasitoid
- Pest control

Asexual reproduction

Many female aphids are capable of producing offspring without the need to mate with a male. This is known as **asexual reproduction**. The female aphid in question gives birth to clones identical to herself. These daughters already have their daughters growing inside them, in a

One of 16 suction traps situated throughout England and Scotland monitoring aerial aphid density

phenomenon known as telescoping of generations. An easy way to understand this is to imagine the female aphid as a Russian doll. She is pregnant with her granddaughters as well as her daughters. This unusual reproductive cycle means very short generation times and fast maturation, which allows the aphid population to build up rapidly, exploiting favourable conditions.

As an example, imagine a hypothetical aphid that can give birth to seven daughters every day. In just 1 week, that aphid has given birth to 49 daughters, all of which already have their daughters developing inside them. In approximately 1 week, the daughters reach sexual maturity and produce daughters for themselves.

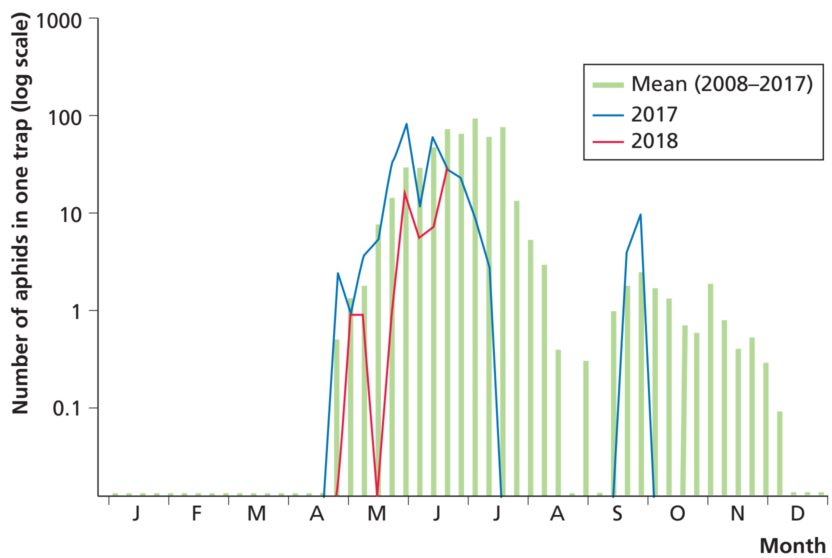
Agricultural impact

This ability of aphids to reproduce rapidly, in combination with the way in which they spread diseases and cause damage to plants when feeding, means that they represent a massive financial burden to farmers. Aphids cause great economic losses through the damage and destruction of crops and the reduction of crop yields (see Box 1).

There are more than 4400 species of aphids, each highly specific to a range of host plants, which means few agricultural crops are safe from their damaging effects. In the UK, for example, the peach-potato aphid (*Myzus persicae*) is a threat to potato, cabbage and other brassica crops including cauliflower, broccoli and Brussels sprouts. Grain aphids such as the English grain aphid (*Sitobion avenae*), the rose-grain aphid (*Metopolophium dirhodum*) and the bird cherry-oat aphid (*Rhopalosiphum padi*) are major threats to cereal crops including wheat, barley, oats and maize. Scientific research has

Box 1 Aphid monitoring at Rothamsted Research

Rothamsted Research, based in Hertfordshire, is the oldest agricultural research station in the world. Since 1964, it has been involved in the long-term monitoring of aphids via a national network of **suction traps**. A total of 16 traps, standing at 12.2 metres tall, are located throughout England and Scotland. They monitor aerial aphid density on a daily basis during peak aphid flying season (April to November), and on a weekly basis for the remainder of the year. The data collected (see Figure 1) are published on the organisation's website (**www.rothamsted.ac.uk/insect-survey**), and provide farmers with invaluable information on the timing and size of aphid migrations. Farmers can use the data to make informed decisions on the level of insecticide application required for their crops and to prevent unnecessary insecticide use.



Source: Rothamsted Research

Figure 1 A graph showing levels of airborne peach-potato aphid (*Myzus persicae*) at Rothamsted produced by Rothamsted Research based on data collected by its network of suction-traps

Terms explained

Asexual reproduction A mode of reproduction in which the offspring arise from a single parent and inherit the genes of that one parent only.

Biological control A method of controlling a pest by introducing a natural enemy (predator, parasite, pathogen) into the environment.

Insecticide resistance The ability of an insect species to become immune to the effects of an insecticide that was previously effective at killing it.

Suction trap A trap that collects flying insects and can be used for estimating the density of airborne insects.

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Aphid infestation on a cabbage leaf


Parasitoid wasp transferring an egg into a peach-potato aphid host

focused on ways to reduce aphid numbers and successfully control their population.

Many chemical-based control methods involve applying insecticides to crops. Concerns about the impacts on human health and our environment mean that researchers are increasingly looking to more environmentally friendly ways to control pest insects. Most chemical insecticides are non-specific, meaning that they target and kill beneficial insects (such as honey bees and other pollinators) as well as pests. Overuse of chemical insecticides has also led to **insecticide resistance** in many important insect pests including aphids. This means that insecticides that were once effective at killing and controlling the pest insect no longer work.

What is biological control?

Biological control involves using living organisms that naturally predate or parasitise the pest in question. This is a natural solution to reducing the pest population to a less damaging level. Although these relationships between predator and prey occur naturally in the wild, human intervention can be used to increase the effectiveness of the process and suppress the pest population. Large numbers of the natural enemy are bred in captivity, and then released into the environment. Some companies specialise in the mass rearing of natural enemies for sale to farmers and crop-growers.

It is not quite as straightforward as simply releasing large numbers of natural enemies into the farmer's field or greenhouse. Scientific research is needed to try to ensure that the introduced natural enemy cannot establish itself in the new environment. This can involve studying the temperature tolerance threshold of the control organism to ensure that, should it escape into the wild, it will be unable to survive or successfully reproduce in the climate of the new habitat. If the natural enemy can establish itself, scientists must be confident that it will not pose a threat to the new environment and become a pest itself (see Box 2).

Parasitoid wasps

Imagine being stung by a wasp, only to then be eaten from the inside-out over the next few days. This is a very real possibility if you are an aphid. These biological control agents are not the common wasps that can be seen buzzing around your sugary drink on a summer afternoon, but a group of tiny wasps, often little over 1 mm in length.

Parasitic wasps, or parasitoids as they are known, belong to the insect order Hymenoptera. They are dependent upon other insects to act as hosts in order to reproduce and complete their life cycle. The wasp hunts out appropriate prey using olfactory cues and stings it. In the process, the wasp transfers (oviposits) an egg into the body of the insect prey.

Box 2 When biological control goes wrong

The cane toad (*Rhinella marina*) is a large terrestrial toad native to South and Central America. Having been used to control pest beetles successfully in Hawaii, it was introduced into Australia in 1935 to control the greyback cane beetle, a major pest of sugar cane crops. Unfortunately, scientists failed to consider the life history and ecology of the cane toad before its introduction, and the story was not one of success for Australia, but rather of national disaster.

First, cane toads like wet environments and not the dry conditions of the sugar-cane fields. Cane toads left the cane fields (and the pest beetle they were supposed to control) in search of more suitable, wetter conditions.

Second, the greyback cane beetle feeds on the top of cane stalks, which can reach 6–8 metres in height. Have you ever known a toad to climb or fly? The predator cane toad could not even reach the pest beetle it was supposed to eat. Combine this with the fact that cane toads are voracious eaters and will eat just about anything they can fit in their mouths, including many native Australian species, and you can see that this introduction was a recipe for disaster (see Biological Sciences Review, Vol. 30, No. 1, pp. 6–9).

The introduction of cane toads to Australia failed to control the cane beetle and the toads themselves have become a problem

The egg soon hatches into a parasitoid young known as a larva, which feeds on the insect prey from the inside. The body of the insect prey provides the developing parasitoid larva with all the nutrients needed to grow into an adult wasp. Once it is large enough, the larva pupates, before shortly hatching into a flying adult wasp, ready to begin its adult life tormenting a new generation of potential insect hosts. Sadly for the insect host, it does not survive the parasitisation process.

The life cycle of these parasitoids could easily feature in a horror story. However, it is this behaviour that makes the parasitoid wasps belonging to the subfamily Aphidiinae so useful to humans. The mass release of these wasps into agricultural landscapes and greenhouses can control aphid populations, minimising crop damage, protecting crop yields and reducing the use of dangerous chemical insecticides (see Further reading for a video link).

Researchers have also investigated ways to alter the agricultural landscape to increase natural populations of parasitoid wasps. One method involves planting specific wild flower varieties around crop fields to provide adult parasitoids with a nectar and pollen food source. Winter-flowering varieties are of particular interest since they may offer a food source to parasitoids in harsh months when food is otherwise scarce. By encouraging parasitoid populations to establish and build up in numbers early in the year, aphid populations may be kept at lower, more manageable levels, preventing potential spring aphid outbreaks and thus minimising crop damage and loss.

Points for discussion

- Why are scientists concerned about reducing the quantity of chemical insecticides used by farmers?
- Rain may wash chemical insecticides into surrounding rivers. How might this affect the river ecosystem?

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Key points

- Aphids are major agricultural pests that can reduce crop yields by feeding on crop plants and by spreading diseases.
- Biological control is a method of pest control in which a natural enemy of a pest is introduced into the environment.
- Parasitoid wasps are small wasps that must lay their eggs within a host insect in order to reproduce. The young parasitoid (larva) develops within the insect host until it is ready to emerge as an adult wasp. In the process, the insect host is killed.
- Parasitoid wasps that use aphids as their hosts offer a valuable way of controlling aphid numbers to reduce crop damage.

Further reading

For a YouTube video showing how parasitoid pest control works go to: **www.tinyurl.com/yaarrvrv**

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